National Aeronautics and Space Administration

Calibrating CERES and VIIRS using CLARREO Pathfinder: Adjustment for the Viewing Geometry Mismatch

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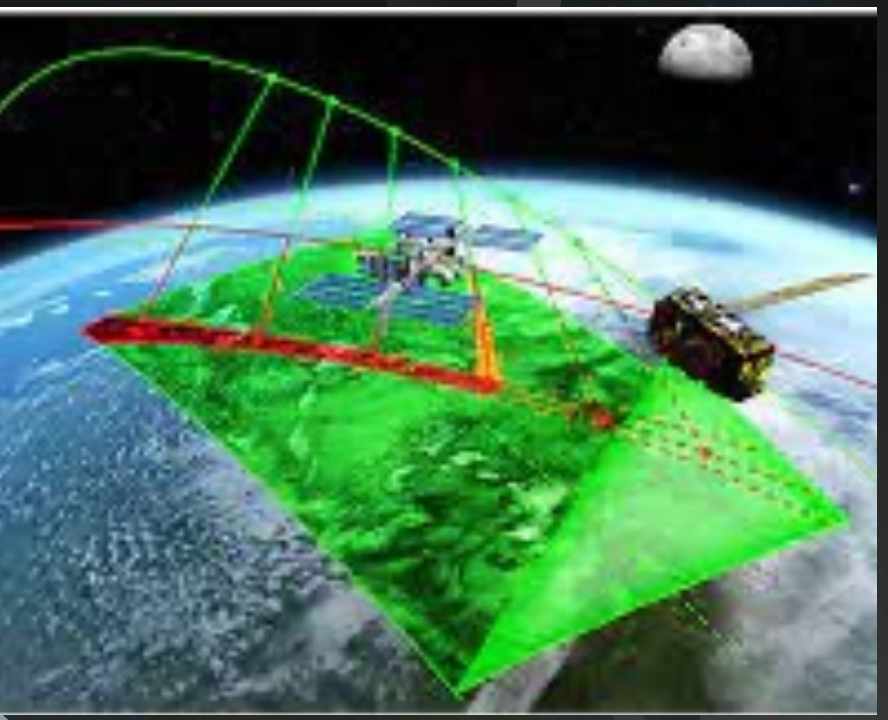
The Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinder Mission



- The CPF mission will demonstrate the ability to provide a high accurate, SI-traceable reference on orbit to inter-calibrate other orbiting instruments.
- A high accuracy reflected solar instrument will be sent to the ISS and take measurements starting in 2023.
- The the inter-calibration for the SW channel of CERES and RS bands of VIIRS will be first demonstrated.
- Algorithms have been developed to facilitate CPF-VIIRS and CPF-CERES inter-calibration data analysis.

Radiometric Uncertainty	0.3% (1-sigma)
Spectral Range	350 – 2300 nm
Spectral Sampling/Resolution	3 nm/6 nm
Polarization Sensitivity	<1%, 350-1800 nm <2%, 1800-2300 nm
Swath Width	10 degrees
Spatial Resolution (nadir)	0.5 km
Sampling Rate	15 Hz

Table 1: Key characteristics of the CPF instrument.

Y. Shea *et al.*, "Clarreo Pathfinder: Mission Overview and Current Status," *IGARSS 2020 - 2020 IEEE International Geoscience and Remote Sensing Symposium*, 2020, pp. 3286-3289, doi: 10.1109/IGARSS39084.2020.9323176.

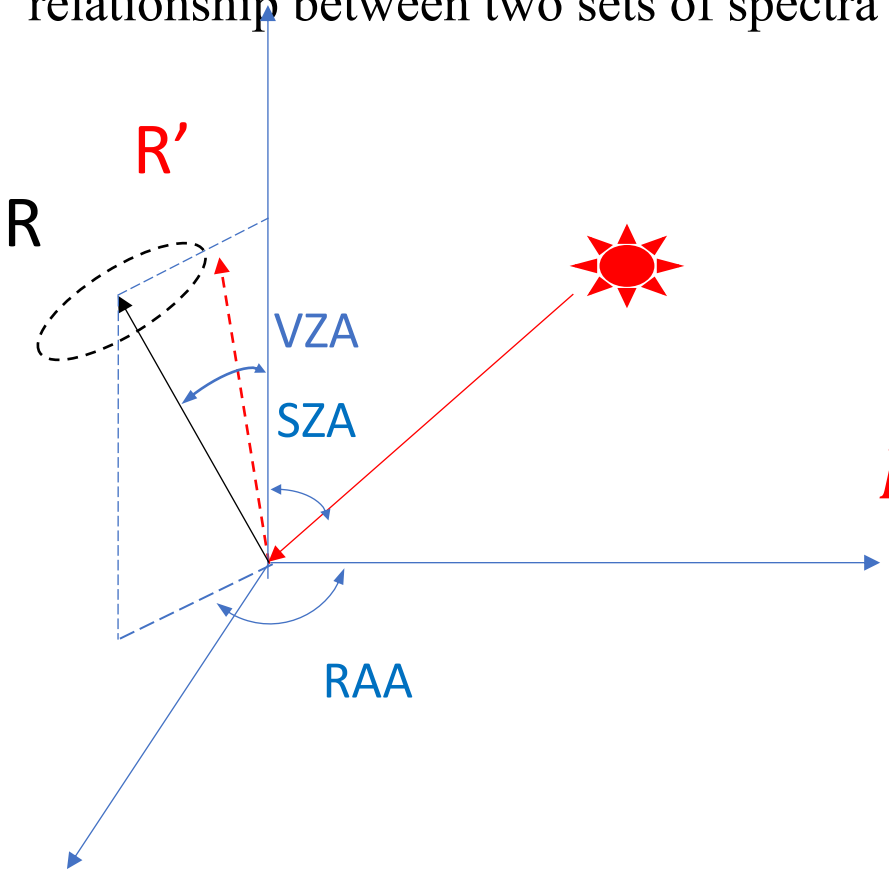
Inter-calibration matching efforts

- Spatial-temporal matching
  - Orbit-modelling to predict inter-calibration events
  - Spatial convolution to match CPF pixel measurements to CERES footprints
  - Spatial convolution to match CPF and VIIRS pixel measurements to overlapping footprints
- Spectral matching
  - Spectral convolution to match CPF spectra to VIIRS RS bands
  - Spectral convolution and spectral gap filling to match CPF spectra to CERES broadband channels
- **Angular matching**
  - **Angular correction for inconsistency between CPF and VIIRS/CERES measurements due to the difference in viewing geometry angles.**

Inter-calibration can't be done on a detector-by detector basis. Sufficient inter-calibration sampling is needed to overcome the random errors from imperfect data matching and instrument noise.

CPF Angular Correction Algorithm

Use on axis-CPF spectra to predict collocated off-axis measurements by utilizing the correlation relationship between two sets of spectra



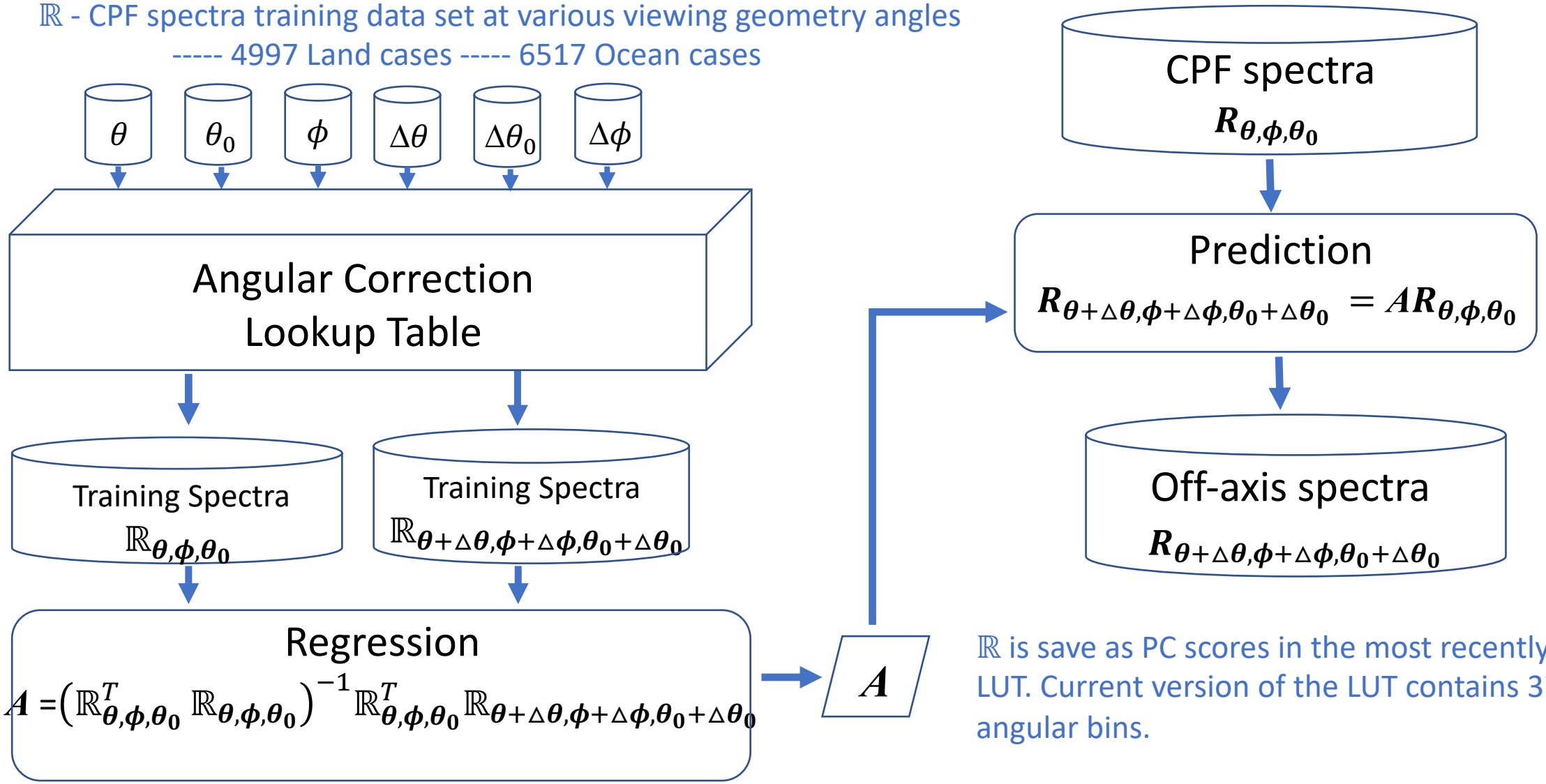
R (BRDF, cloud properties, aerosol, …
VZA, SZA, RAA)

R' (BRDF, cloud properties, aerosol, …
VZA+ΔVZA, SZA+ΔSZA, RAA+ΔRAA)

$$R' = A^T R \qquad A = (RR^T)^{-1} R\, R'^T$$

Angular Correction Algorithm –LUT based approach

$\mathbb{R}$ - CPF spectra training data set at various viewing geometry angles
----- 4997 Land cases ----- 6517 Ocean cases

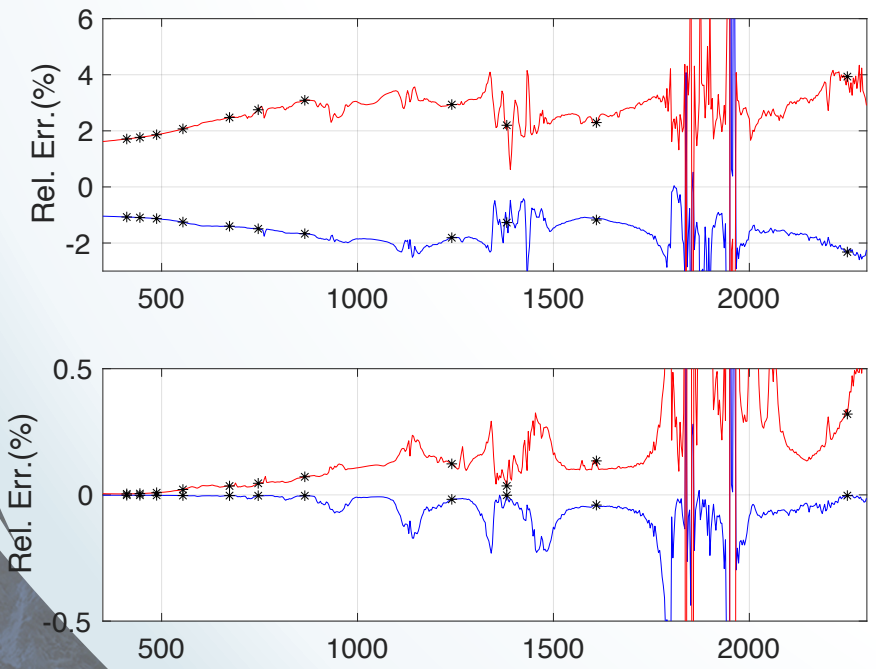


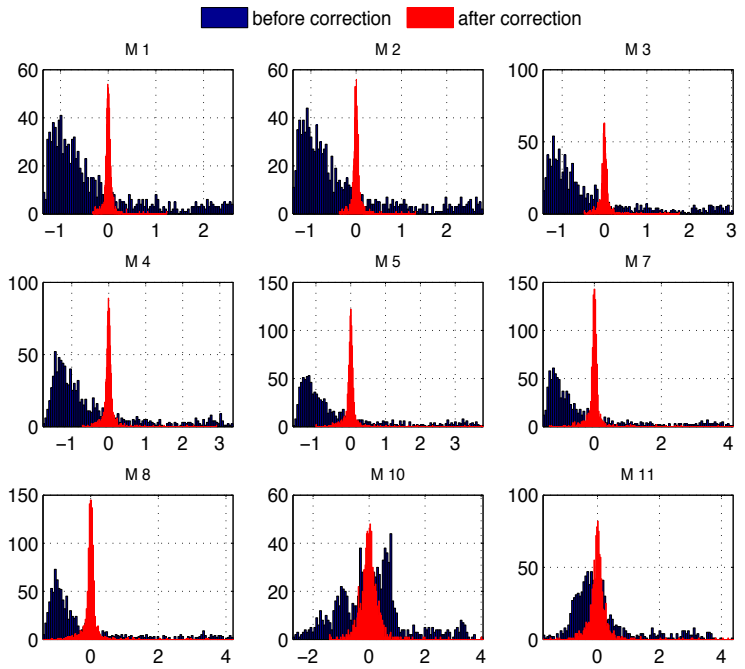
$\mathbb{R}$ is save as PC scores in the most recently updated LUT. Current version of the LUT contains 37*24*21 angular bins.

Angular Correction Study using selected training samples

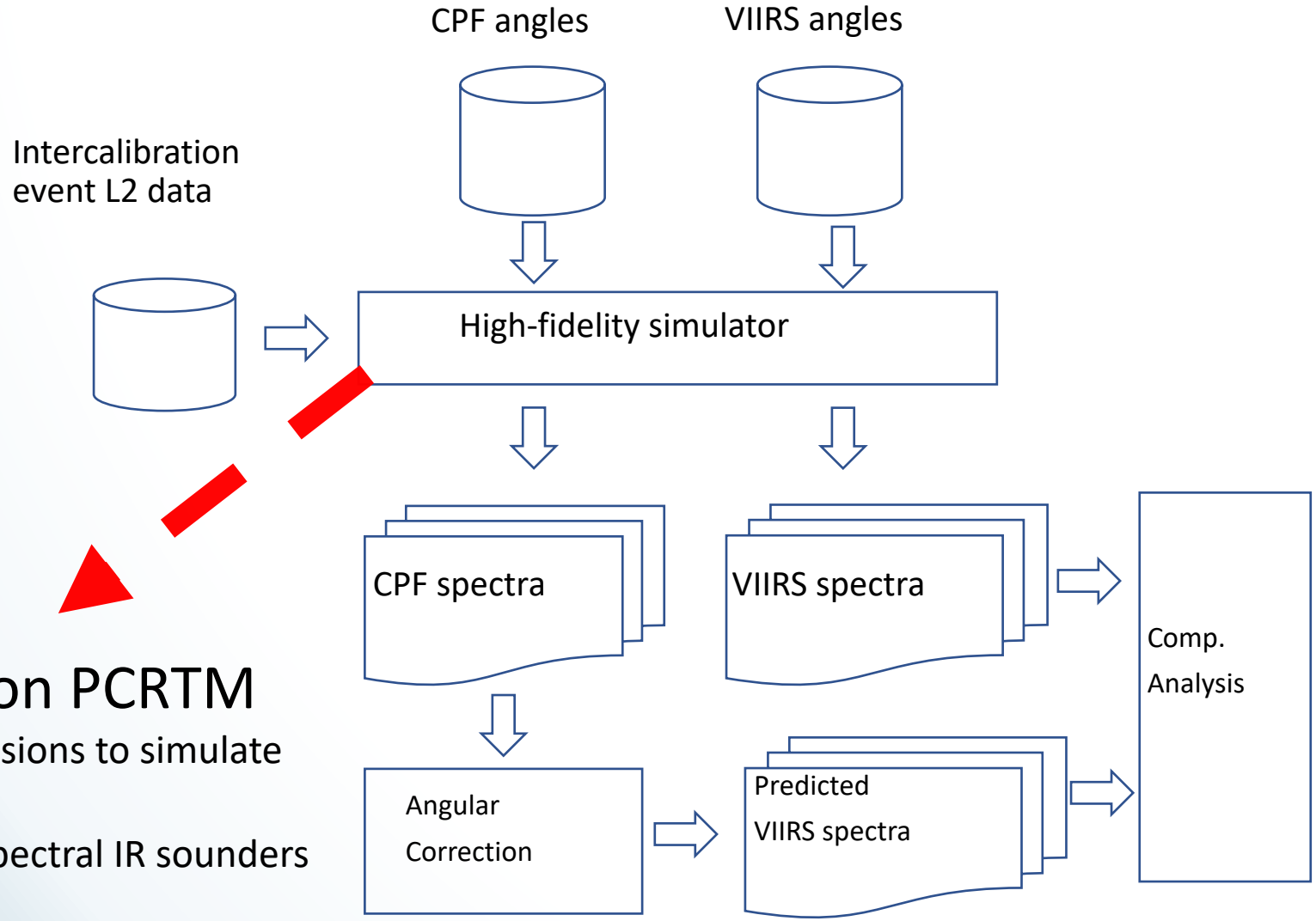
- Use spectral information to address the scene dependent relationship
- Systematic angular mismatch error can be effectively reduced; The error residue after angular correction becomes more random-like noise.

θ=46.1°, ϕ=135.0°,θ_0=40.0°, $\Delta\theta$=2.9°, $\Delta\phi$=5.0°





Algorithm Development and Validation Using High-fidelity Simulation Data

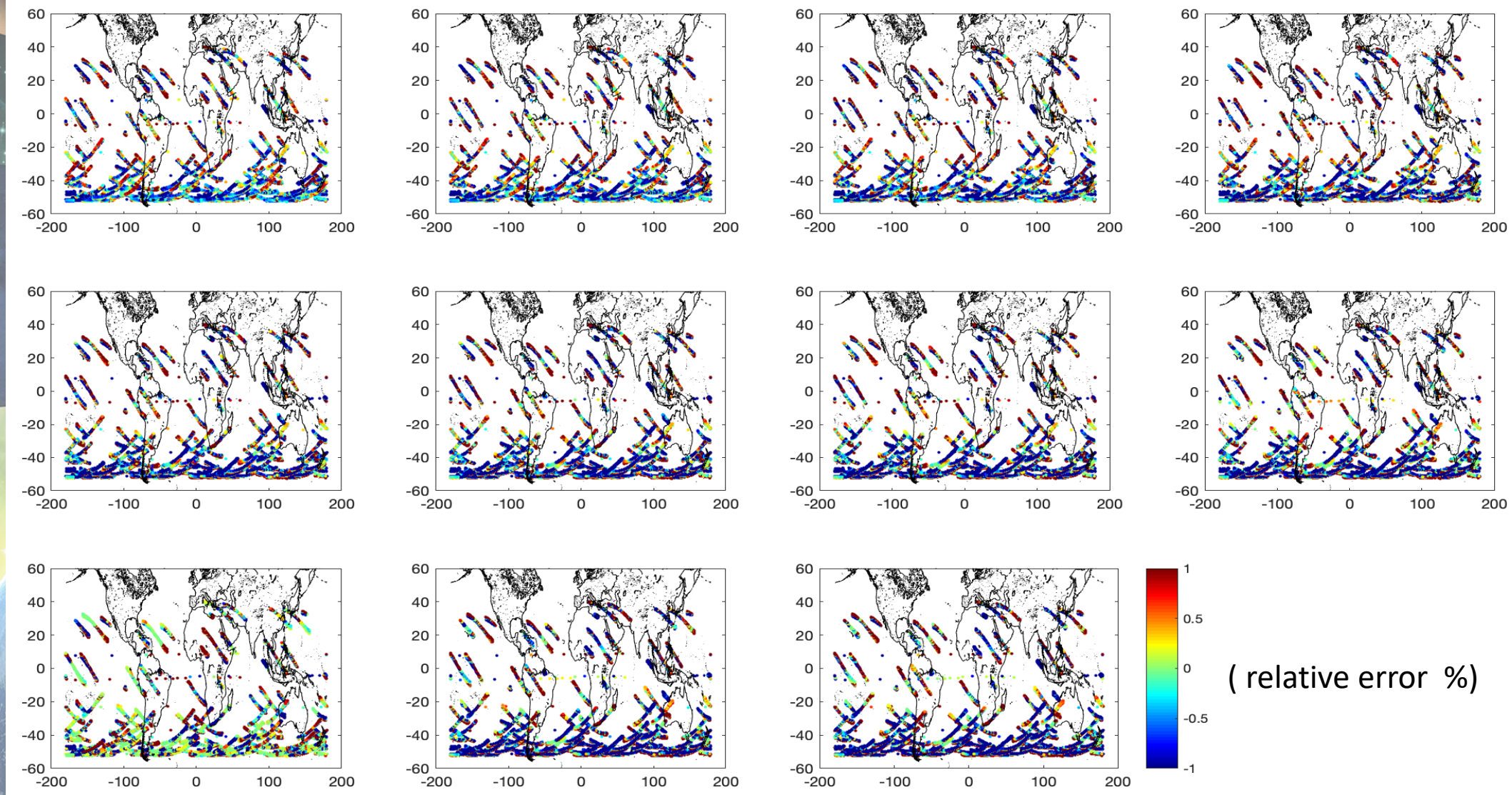


Based on PCRTM

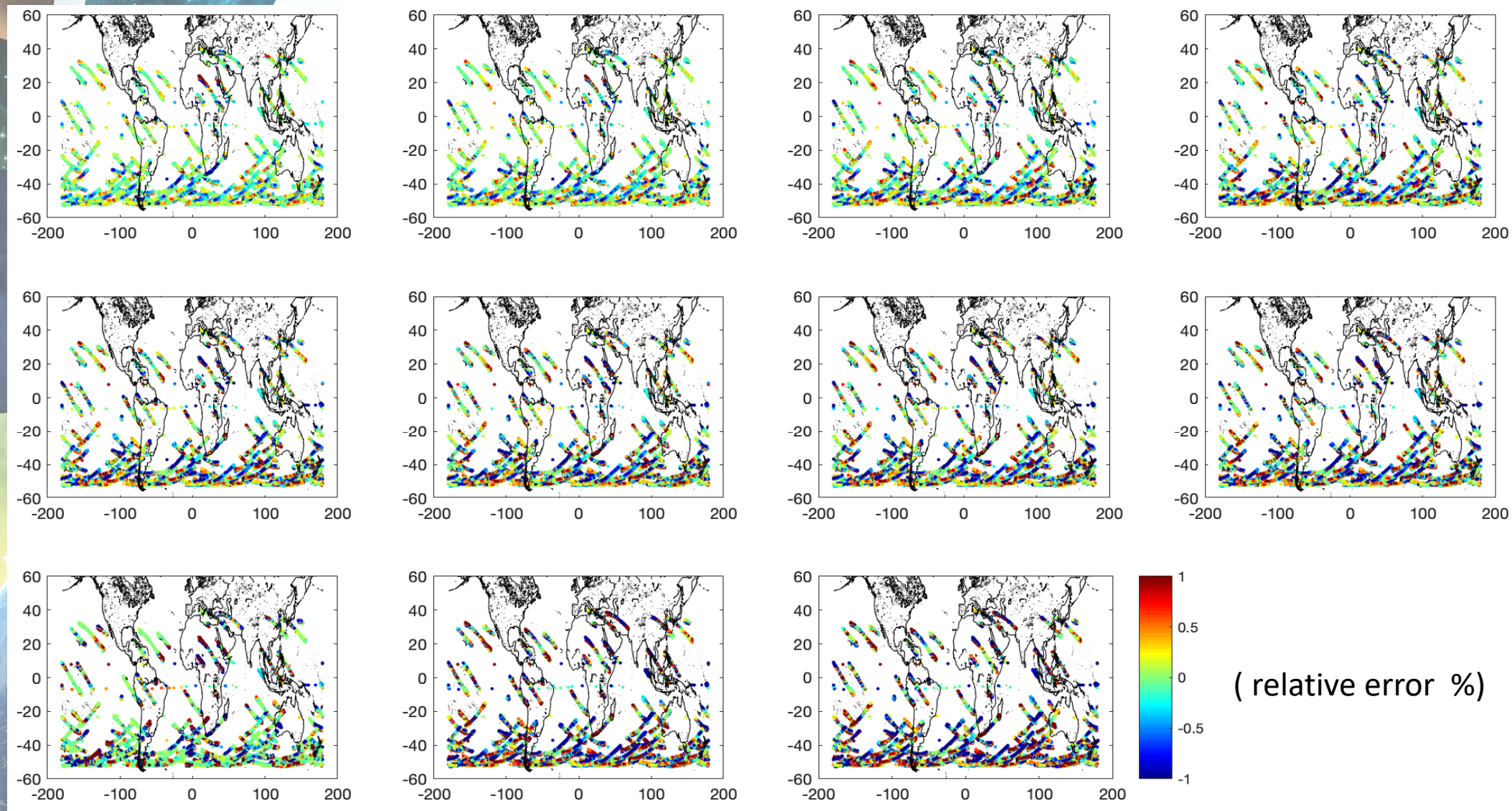
PCRTM has been developed for various missions to simulate hyperspectral observations:

SBG, OMI, TEMPO, as well as major hyperspectral IR sounders

CPF-VIIRS Angular Mismatch Errors of Jan, 2017 (from the High-Fidelity simulator)

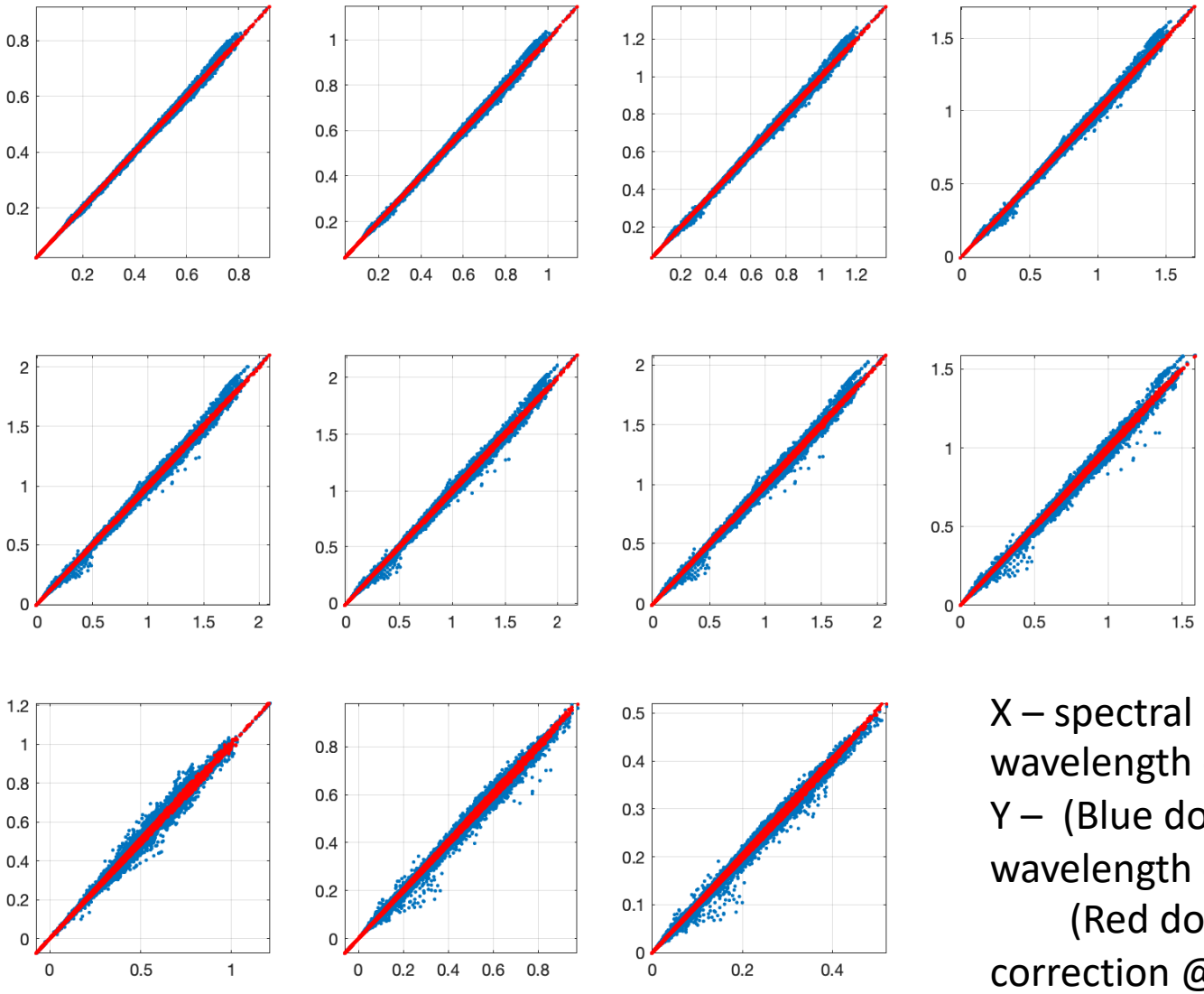


CPF-VIIRS Angular Mismatch Errors of Jan, 2017 (after correction)



(relative error %)

CPF-VIIRS Angular Correction Scatter plots



X – spectral radiance (VIIRS angles) @ the center wavelength of VIIRS M bands

Y – (Blue dots) spectral radiance (CPF angles)@ the center wavelength of VIIRS M bands

(Red dots) mean spectral radiance after angular correction @ the center wavelength of VIIRS M bands

Unit $mW \cdot \mathbf{sr^{-1}} \cdot cm^{-2} / cm^{-1} / nm$

SUMMARY

- The development of inter-calibration methods is well underway, and the implementation will be ready for the inter-calibration of CERES and VIIRS once real CPF data is available.

- The application of algorithms for CPF-CERES/VIIRS inter-calibration, once validated, paves a way for future applications on a wide range of Earth observing systems.

- Before high-accuracy on-orbit references like CPF become available, the methodology can be used for the inter-calibration study using hyper-spectral sensors (e.g. SCIAMACHY), which are valuable to serve as references to mitigate the spectral band difference between sensors.

END